* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]In starting a control device, for example, positioning a robot etc., this invention relates to the control device which performs feedback control and feed-forward control to the control-objectives value which is given discretely as for time.
[0002]
[Description of the Prior Art]For example, the operation of control-objectives values, such as angle of rotation of the motor for a robot drive, performed when performing positioning control, such as a robot, is usually very complicated. For this reason, it is difficult for real time to generate a control-objectives value, and comparatively long time it will consider that is discrete is required for that operation, in view of the control device which is downstream. So, in the control device which is downstream, operation of obtaining a continuous control-objectives value is performed by interpolating the above-mentioned control-objectives value. Thus, an example of the control device which controls by interpolating to the desired value given discretely is shown in drawing 15. The desired value generation machine 101 with which the above-mentioned control device generates the desired value over angle of rotation of the motor 100, for example as shown in drawing 15, The sampler 1021 which takes out the desired value over angle of rotation generated with the above-mentioned desired value generation machine 101 with a predetermined sampling period, The linear interpolation machine 1031 which carries out linear interpolation of the desired value over the above-mentioned angle of rotation taken out for every predetermined sampling period by the above-mentioned sampler 1021 in time, The feedback loop (FB loop is called hereafter) 104 which performs feedback control about angle of rotation and revolving speed of the above-mentioned motor 100 based on the desired value over the above-mentioned angle of rotation interpolated with the above-mentioned linear interpolation machine 1031, Feedforward loop 104 (FF loop is called hereafter) 105 is provided about angle of rotation and roll acceleration of the above-mentioned motor 100. In the above-mentioned control device, the desired value over angle of rotation of the above-mentioned

motor 100 generated with the above-mentioned desired value generation machine 101 is taken out by the above-mentioned sampler 1021 with a predetermined sampling period, and is supplied to the above-mentioned linear interpolation machine 1031. The desired value over the above-mentioned angle of rotation which became continuous for linear interpolation to be carried out in time with the above-mentioned linear interpolation machine 1031 is supplied to the above-mentioned FB loop 104 and the FF loop 105. It is fed back by angle of rotation of the actually measured above-mentioned motor 100 in the above-mentioned FB loop 104, and with the above-mentioned linear interpolation machine 1031. A deviation with the desired value over angle of rotation by which linear interpolation was carried out is inputted into the position gain 1041, and the desired value over the revolving speed of the above-mentioned motor 100 is outputted from the above-mentioned position gain 1041. Angle of rotation of this and the above-mentioned motor 100 actually measured in parallel is differentiated with the differentiator 1042, and is changed into revolving speed. A deviation with the desired value over this actual revolving speed and the revolving speed outputted from the above-mentioned position gain 1041 is supplied to the speed controller 1043, and the desired value over the roll acceleration of the above-mentioned motor 100 is outputted from the above-mentioned speed controller 1043. The desired value over this roll acceleration, i.e., a thrust command, is supplied to the above-mentioned motor 100, and the above-mentioned motor 100 drives according to it. Controlled variables, such as the above-mentioned angle of rotation outputted from the above-mentioned motor 100, can be made to follow the above-mentioned desired value to some extent by performing feedback control about angle of rotation and revolving speed of the above-mentioned motor 100 by the above-mentioned FB loop 103. However, as shown in drawing 16, in this flattery, a big time delay arises in many cases. In above-mentioned drawing 16, the controlled variable is shown by the dashed line about the desired value over angle of rotation which is shown as a solid line and by which linear interpolation was carried out. The above-mentioned FF loop 105 is for canceling this time delay. In the above-mentioned FF loop 105, the desired value over the above-mentioned angle of rotation by which linear interpolation was carried out with the above-mentioned linear interpolation machine 1031 with the differentiator 1051 and the proportionality differentiator 1052. It is changed into the desired value over the revolving speed and roll acceleration of the above-mentioned motor 100, respectively, and is added to the output of the position gain 1041 in the above-mentioned FB loop 104, and the speed controller 1043, respectively. Here, the ideal (continuous) desired value (thin dashed line) over angle of rotation in the above-mentioned control device, the desired value (solid line) after linear interpolation, and an example of a actual controlled variable (dashed line) are shown to drawing 2. When it controls also using the above-mentioned FF loop 105 to be shown in drawing 2 in addition to the above-mentioned FB loop 104, the desired value over the original above-mentioned angle of rotation shown with a thin dashed line without a time delay almost arising between the actual controlled variables (angle of rotation) shown with a dashed line if the desired value is originally continuous as shown by the thin dashed line -- the above -- the response of a actual controlled variable is improvable.

[0003]
[Problem(s) to be Solved by the Invention]By the way, in the above conventional control devices, after linear interpolation is performed by the linear interpolation machine 1031 to the desired value over the above-mentioned angle of rotation generated discretely, differentiation operation is performed by the differentiators 1051 and 1052 of the above-mentioned FF loop 105. That is, differentiation operation will be performed after the desired value over the above-mentioned angle of rotation given discretely every 0.1 s, for example is interpolated by the straight line. For this reason, to the ideal desired value shown with the thin dashed line of drawing 17, the desired value over the revolving speed of the above-mentioned motor 100 outputted from the differentiator 1051 of the above-mentioned FF loop 105 will change to step form, as the solid line of drawing 17 shows. As the solid line of drawing 17 shows, when the desired value over the above-mentioned revolving speed changes to step form, it is difficult to change the speed of the above-mentioned motor 100 in the secondary system that drives the motor 100 using the desired value over the interpolated above-mentioned revolving speed. When it controls using the desired value over the above-mentioned revolving speed which changed to step form, as shown in drawing 18 and drawing 19, respectively, this, It is for causing the practical big problem of producing with **** in angle of rotation and revolving speed of the above-mentioned motor 100, and exciting the natural frequency of the load of the above-mentioned motor 100. In order that this invention might solve SUBJECT in such a Prior art, for example, it improved the control device and was generated discretely, by a desired value to differentiation operation to positions, such as angle of rotation. Even when controlling by generating desired values, such as revolving speed, it sets it as the main purposes to provide the control device which prevents the problem of exciting the natural frequency of load from arising, and performs stable control. and the above -- one to be contained in the main purposes. After differentiation operation generates the desired value over speed etc. from the desired value over the position generated discretely, it is providing the control device which can prevent the desired value over the above-mentioned speed etc. from changing to step form by performing linear interpolation. Other one is providing the control device which can prevent the desired value over the speed etc. which are generated by differentiation operation from changing from the desired value over the above-mentioned position to step form by performing secondary high order more than interpolation about the desired value over the position generated discretely. In performing high order interpolation especially, there is a possibility that the desired value itself may oscillate at the time of high order interpolation, but it is also one of the purposes to prevent this.
[0004]
[Means for Solving the Problem]To achieve the above objects, an invention concerning claim 1, A position target value creating means which generates a desired value over a position of a subject with a predetermined time interval, A position interpolation means which interpolates in time the primary desired value over a position generated by the above-mentioned position target value creating means, In a control device possessing a feedforward control means which performs feed-forward

control about speed and acceleration of the above-mentioned subject, A speed target value generating means which generates a desired value over speed of the above-mentioned subject with a predetermined time interval based on a desired value over a position of the above-mentioned subject generated by the above-mentioned position target value creating means, Provide a speed interpolation means which carries out linear interpolation of the desired value over speed generated by the above-mentioned speed target value generating means in time, and the above-mentioned feedforward control means by the above-mentioned speed interpolation means. It is constituted as a control device controlling based on a desired value over interpolated speed. An invention concerning claim 2 possesses a feedback control means which performs feedback control about a position and speed of the above-mentioned subject based on a desired value over a position interpolated in above-mentioned claim 1 by the above-mentioned position interpolation means in a control device of a statement, and makes things the gist. In above-mentioned claim 1 or a control device given in 2 an invention concerning claim 3, An acceleration target value generating means which generates a desired value over acceleration of the above-mentioned subject with a predetermined time interval based on a desired value over a position of the above-mentioned subject generated by the above-mentioned position target value creating means, Provide an acceleration interpolation means which carries out linear interpolation of the desired value over acceleration generated by the above-mentioned acceleration target value generating means in time, and the above-mentioned feedforward control means by the above-mentioned speed interpolation means. It is constituted as the control device according to claim 1 or 2 which controls based on a desired value over interpolated speed, and a desired value over acceleration interpolated by the above-mentioned acceleration interpolation means. When only a predetermined time interval requires time for generation of a desired value over a position of a subject generated from a position target value creating means according to the control device given in any 1 paragraph of above-mentioned claims 1-3, a desired value over the above-mentioned position by for example, speed target value generating means, such as a differentiator. Since linear interpolation is performed by the above-mentioned speed interpolation means after changing into a desired value over speed of the above-mentioned subject, in feed-forward control to speed of the above-mentioned subject, a desired value over the above-mentioned speed is prevented from changing to step form at least, and it can stabilize control. an invention concerning claim 4 -- the Nth system -- with a target value generating means which generates a desired value over a position of a subject (N is two or more integers) with a predetermined time interval. In a control device which possesses a feedforward control means which performs feed-forward control about speed, --, the Nth differential quantity of a position based on a desired value over a position generated by the above-mentioned target value generating means, It is constituted as a control device, wherein it provides secondary -- or an interpolation means interpolated the Nth order and the above-mentioned feedforward control means controls a desired value over a position of the above-mentioned subject based on a desired value over the above-mentioned position interpolated by the above-mentioned interpolation means. In a control device given in above-mentioned claim 4 an invention concerning

claim 5, The control device according to claim 4 which possesses further a feedback control means which performs feedback control about a position, --, the following (N-1) differential quantity of a position based on a desired value over the above-mentioned position interpolated by the above-mentioned interpolation means. In above-mentioned claim 4 or a control device given in 5 an invention concerning claim 6, To a desired value over a position at the time of [a certain] being generated by the above-mentioned target value generating means, at least, using a desired value over a position at the N time including a time of the account of the upper being, a smoothing means which smooths a desired value over the above-mentioned position is provided, and let things be the gist. An invention concerning claim 7 makes it the gist to be what smooths a desired value over the above-mentioned position, when the above-mentioned smoothing means performs moving average processing with dignity to above-mentioned claim 6 in a control device of a statement. In a control device given in above-mentioned claim 7 an invention concerning claim 8, The above-mentioned predetermined time interval is certain time interval deltaT, and when the above-mentioned interpolation means performs Nth interpolation, let it be the gist coefficient a_1 provided in dignity of moving average processing with dignity performed by the above-mentioned smoothing means based on a following formula, --, to use a_n and --a_N.

[Equation 2]

$$a_n = \int_{t_{n-1}}^{t_n} P_N(t)dt$$

$$P_N(t_N) = \int_0^{t_N} P_1(t-t_{N-1})P_{N-1}(t_{N-1})dt_{N-1} = \int_0^{t_N} P_1(t-t_{N-1})\int_0^{t_{N-1}} P_1(t-t_{N-2})\cdots\int_0^{t_1} P_1(t-t_0)I(t_0)dt_0\cdots dt_{N-2}dt_{N-1}$$

$$P_1(t) = S(\Delta T, t)$$

$$I(t) = \lim_{x\to 0} S(x,t)$$

$$S(x,t) = \begin{cases} 1/x\ (0 \le t < x) \\ 0\ (t<0,\ x \le t) \end{cases}$$

In a control device given in above-mentioned claim 7, the above-mentioned predetermined time interval is changed serially, and the invention concerning claim 9 defines the dignity of the moving average processing with the above-mentioned dignity according to change of the above-mentioned predetermined time interval, and makes things the gist. In above-mentioned claim 8 or a control device given in 9 the invention concerning claim 10, The dignity of the moving average processing with the above-mentioned dignity makes it the gist to come to set total of an impulse response series based on the function from which from the desired value and the first floor differential value of its after the moving average processing with dignity after 1 and N samplings (N-1) to a story differential value is set to 0. The invention concerning claim 11 makes it the gist for the above-mentioned smoothing means to add predetermined dynamic characteristics to the moving average processing with dignity in a control device given in any 1 paragraph of above-mentioned claims 6-10. The invention concerning claim 12 corrects the desired value interpolated in any 1 paragraph of above-mentioned claims 4-11 by the above-mentioned interpolation means in the control device of a statement using

the desired value generated by the above-mentioned target value generating means, and makes things the gist. In a control device given in any 1 paragraph of above-mentioned claims 4-12, the above-mentioned interpolation means is provided with the above-mentioned smoothing means, and the invention concerning claim 13 makes things the gist. According to the control device given in any 1 paragraph of above-mentioned claims 4-13, since Nth high order more than interpolation is performed about the desired value over the position of N next system subject, each desired value can be prevented from changing with the differentiation operations in the case of control to rectangle step form, and control can be stabilized more. The oscillation of the desired value after the interpolation at the time of high order interpolation can be prevented by performing data smoothing which added predetermined dynamic characteristics to the moving average processing with dignity, or it especially.

[0005]
[Embodiment of the Invention]Hereafter, with reference to an accompanying drawing, it explains per embodiment of the invention, and an understanding of this invention is presented. Following embodiments are concrete examples of this invention, and are not the things of the character which limits the technical scope of this invention. The control device A1 concerning the 1 embodiment of this invention is equivalent to the invention concerning claims 1-3, and is materialized as a control device which positions the motor which drives a robot. The outline composition of the control device A1 concerning the 1 embodiment of this invention is shown in drawing 1. The above-mentioned control device A1, for example a robot. Positioning of the motor to drive. As it is a control device for carrying out and is shown in drawing 1, the motor 100. The desired value generation machine 101 and the sampler 1021 (equivalent to a position target value creating means) which generate the desired value over angle of rotation (an example of a position) of (an example of a subject) with a predetermined sampling period, The linear interpolation machine 1031 (equivalent to a position interpolation means) which interpolates in time the primary desired value over the above-mentioned angle of rotation generated with the above-mentioned desired value generation machine 101, Based on the desired value over the above-mentioned angle of rotation interpolated by the above-mentioned position interpolator 1031, about angle of rotation and revolving speed of the above-mentioned motor 100. The feedback loop (considerable and a following FB loop are called to a feedback control means) 104 which performs feedback control, It is the same as that of the thing conventional at the point of providing the feedforward loop 105 (considerable and a following FF loop are called to a feedforward control means) which performs feed-forward control about the revolving speed and roll acceleration of the above-mentioned motor 100, almost. The above-mentioned control device A1 differing from the conventional thing, With the above-mentioned desired value generation machine 101. The differentiator 1012 and the sampler 1022 (equivalent to a speed mark value creating means) which generate the desired value over the revolving speed of the above-mentioned motor 100 with a predetermined sampling period based on the desired value over angle of rotation of the above-mentioned motor 100 generated, The linear interpolation machine 1032 (equivalent to a speed

interpolation means) which carries out linear interpolation of the desired value over the above-mentioned revolving speed generated by the above-mentioned differentiator 1012 in time, With the above-mentioned desired value generation machine 101. With the differentiator 1013 and the sampler 1023 (equivalent to an acceleration target value generating means) which generate the desired value over the roll acceleration of the above-mentioned motor 100 with a predetermined sampling period based on the desired value over the rotary place of the above-mentioned motor 100 generated, and the above-mentioned differentiator 1013. Provide the linear interpolation machine 1033 (equivalent to an acceleration interpolation means) which carries out linear interpolation of the desired value over the generated above-mentioned roll acceleration in time, and the above-mentioned FF loop 105 with the above-mentioned linear interpolation machine 1032. It is a point which controls based on the desired value over the above-mentioned roll acceleration by which linear interpolation was carried out to the desired value over the above-mentioned revolving speed by which linear interpolation was carried out with the above-mentioned linear interpolation machine 1033. Next, the details of the above-mentioned control device A1 are explained. The above-mentioned desired value generation machine 101 calculates and generates the desired value over angle of rotation of the above-mentioned motor 100 for positioning the motor 100 which drives a robot, for example, and is realized by the buffer etc. which hold temporarily calculating means and the results of an operation, such as CPU. The above operations are complicated in many cases, and calculation time it considers that is discrete is required for them, in view of the control system which is downstream. The output of the above-mentioned desired value generation machine 101 is connected to the sampler 1021 by the side of the FB loop 104, and the differentiator 1012 by the side of the FF loop 105. By the above-mentioned sampler 1021, the desired value over the above-mentioned angle of rotation outputted from the above-mentioned desired value generation machine 101 is taken out with a predetermined sampling period, for example, a sampling period fixed for 0.1 s, and is supplied to the linear interpolation machine 1031. After linear interpolation is carried out with the above-mentioned linear interpolation machine 1031, the desired value over the above-mentioned angle of rotation is outputted to the above-mentioned FB loop 104. It is fed back by angle of rotation of the actually measured above-mentioned motor 100 in the above-mentioned FB loop 104, and with the above-mentioned linear interpolation machine 1031. A deviation with the desired value over angle of rotation by which linear interpolation was carried out is inputted into the position gain 1041, and the desired value over the revolving speed of the above-mentioned motor 100 is outputted from the above-mentioned position gain 1041. Angle of rotation of this and the above-mentioned motor 100 actually measured in parallel is differentiated with the differentiator 1042, and is changed into revolving speed. A deviation with the desired value over this actual revolving speed and the revolving speed outputted from the above-mentioned position gain 1041 is supplied to the speed controller 1043, and the desired value over the roll acceleration of the above-mentioned motor 100 is outputted from the above-mentioned speed controller 1043. The desired value over this roll acceleration, i.e., a thrust command, is supplied to the above-mentioned motor 100, and the above-mentioned motor 100 drives according to

it. In the above-mentioned differentiator 1012, about the desired value over angle of rotation outputted from the above-mentioned desired value generation machine 101, differentiation operation is performed and the desired value over the revolving speed of the above-mentioned motor 100 is outputted. Differentiation operation of the output of the above-mentioned differentiator 1012 is further carried out by the differentiator 1013, and the desired value over the roll acceleration of the above-mentioned motor 100 is generated. And the desired value over the above-mentioned revolving speed and roll acceleration which are outputted from the above-mentioned differentiators 1012 and 1013, respectively is taken out with a predetermined sampling period by the samplers 1032 and 1033, respectively, and is supplied to the linear interpolation machines 1032 and 1033. After linear interpolation of the desired value over the above-mentioned revolving speed and roll acceleration is carried out with the above-mentioned linear interpolation machines 1022 and 1023, it is outputted to the above-mentioned FF loop 105. The desired value over the above-mentioned revolving speed by which linear interpolation was carried out with the above-mentioned linear interpolation machine 1022 is added to the output of the above-mentioned position gain 1041, and the control delay about the above-mentioned revolving speed is compensated with the above-mentioned FF loop 105. The desired value over the above-mentioned roll acceleration by which linear interpolation was carried out with the above-mentioned linear interpolation machine 1023 is added to the output of the above-mentioned speed controller 1043 via proportional element 1052', and the control delay about the above-mentioned roll acceleration is compensated. Here, an example of a desired value to the above-mentioned angle of rotation and revolving speed by which linear interpolation was carried out, respectively with the above-mentioned linear interpolation machine 1031 and the above-mentioned linear interpolation machine 1032 is shown in drawing 2 and drawing 3. In drawing 2 and drawing 3, the continuous desired value over the above-mentioned angle of rotation and revolving speed is shown by the thin dashed line, the desired value by which linear interpolation was carried out, respectively is shown by the solid line, and a actual controlled variable is shown by the dashed line. In the above-mentioned control device A1, the desired value over the above-mentioned revolving speed, Since linear interpolation is carried out with the above-mentioned linear interpolation machine 1032 after the desired value over the above-mentioned angle of rotation differentiates with the above-mentioned differentiator 1012, as shown in drawing 3, the desired value supplied to the above-mentioned FF loop 105 does not change to rectangle step form, but is changing in the shape of a polygonal line. The shape of a changed form of a desired value is the same as that of a desired value [as opposed to the above-mentioned revolving speed at the point interpolated in the shape of / of a different thing / a polygonal line] also about the desired value over the above-mentioned roll acceleration. By controlling by supplying the desired value over the above-mentioned revolving speed and roll acceleration which change in the shape of a polygonal line in this way to the above-mentioned FF loop 105, it can reduce with **** which appears when performing differentiation operation after performing linear interpolation conventionally, and stable control can be performed. Next, the control device A2 concerning other embodiments of this invention is explained. The above-

mentioned control device A2 is equivalent to the invention concerning claims 4-11, and shape is taken as a control device which positions the motor which drives a robot as well as [for example,] the above-mentioned control device A1. The outline composition of the above-mentioned control device A2 is shown in drawing 4. As shown in drawing 4, the above-mentioned control device A2 with the desired value generation machine 101 and the sampler 1021 (equivalent to a position target value creating means) which generate the desired value over angle of rotation (an example of a position) of the motor 100 (an example of a subject) with a predetermined sampling period, and the above-mentioned desired value generation machine 101. The FB loop 104 which performs feedback control about revolving speed and roll acceleration based on the desired value over the generated position, It is the same as that of the thing conventional at the point of providing the FF loop 105 which performs feed-forward control about revolving speed and roll acceleration based on the desired value over the position generated with the above-mentioned desired value generation machine 101, almost. That the above-mentioned control device A2 divides with the conventional thing, and differ, The rectifier 201 which adds correction which performs moving average processing with dignity to the desired value over the above-mentioned angle of rotation generated with the above-mentioned desired value generation machine 101, Provide the high order interpolator 202 (equivalent to an interpolation means) which performs 3rd high order interpolation about the desired value over the above-mentioned angle of rotation corrected by the above-mentioned rectifier 201, and the above-mentioned FF loop 105 by the above-mentioned high order interpolator 202. It is a point which controls based on the desired value over the above-mentioned angle of rotation by which high order interpolation was carried out. Next, the details of the above-mentioned control device A2 are explained. The same explanation as the above-mentioned control device A1 is omitted as long as there is no necessity. In the above-mentioned control device A2, 3rd high order interpolation is performed to the desired value over angle of rotation of the above-mentioned motor 100 taken out with the predetermined sampling period by the sampler 1021 by the high order interpolator 202, for example, and it is outputted to it to the above-mentioned FF loop 105. In the above-mentioned FF loop 105, the first degree differentiation operation is made with the above-mentioned differentiator 1051 by the desired value over the above-mentioned angle of rotation outputted from the above-mentioned high order interpolator 202, and the first degree differentiation operation is further made by the output of the above-mentioned differentiator 1051 with the above-mentioned proportionality differentiator 1052. Namely, the desired value over the revolving speed of the above-mentioned motor 100 outputted from the above-mentioned differentiator 1051, It is that to which differentiation operation of the first degree was performed about the desired value over the above-mentioned angle of rotation outputted from the above-mentioned high order interpolator 202. It is and differentiation operation of the second degree is performed about the desired value over the above-mentioned angle of rotation to which the desired value over the roll acceleration of the above-mentioned motor 100 outputted from the above-mentioned proportionality differentiator 1052 was outputted from the above-mentioned high order interpolator 202. Even if these differentiation operations are performed, the output of the above-

mentioned differentiator 1051 or the above-mentioned proportionality differentiator 1052 does not change to rectangle step form. This is because between each sampling point of a desired value to the above-mentioned angle of rotation is interpolated by the above-mentioned high order interpolator 202 with the 3rd curve. if the above-mentioned FF loop 105 performs feed-forward control using such a comparatively smooth desired value, a desired value will arise by changing to step form -- flustering -- etc. -- it can stop. However, in performing high order interpolation, according to the sampling of the desired value over the above-mentioned angle of rotation, there is a possibility that the desired value after high order interpolation itself may oscillate. For example, supposing a step input as shown in O seal of drawing 5 is given to the above-mentioned high order interpolator 202 from the above-mentioned sampler 1021, more than in the secondary high order interpolation. To the frequency of pi/delta T (deltaT; sampling period), as a thin dashed line shows, the desired value after interpolation oscillates, and there is a possibility of becoming unstable. This tendency becomes still stronger when the input of the above-mentioned high order interpolator 202 changes in vibration. So, in the above-mentioned control device A2, before high order interpolation is carried out by the above-mentioned high order interpolator 202, the desired value over the above-mentioned angle of rotation generated with the above-mentioned desired value generation machine 101 is supplied to the rectifier 201. Desired value u (k) (k) to the above-mentioned angle of rotation to which the above-mentioned rectifier 201 is outputted from the above-mentioned desired value generation machine 101 It receives that it is shown that it is one or more integers and is the k-th sampling. It is constituted by the memory for buffering the desired value over the above-mentioned angle of rotation of three or more pieces which includes the time concerned to the desired value over the above-mentioned angle of rotation at the time of [a certain] moving average processing with a calculating means and dignity in which moving average processing with dignity is performed being carried out, etc. For example, if the desired value over the above-mentioned angle of rotation of k is set to x (k) a certain time of being outputted from the above-mentioned rectifier 201, the operation of the moving average processing with the above-mentioned dignity will be performed, for example based on a following formula.

$x(k) = a_1 xu(k+1) + a_2 xu(k) + a_3 xu\ (k-1)$

Here, the above-mentioned a_1, a_2, and a_3 are weighting factors defined according to sampling period deltaT. The transfer functions of the rectifier 201 are $(a_1 z + a_2 z + a_3 z^{-1}) / 1$ at this time. By performing such moving average processing with dignity, as x seal of drawing 5 shows, the desired value over the above-mentioned angle of rotation outputted from the above-mentioned desired value generation machine 101 is corrected. The value at the time of 0.2s and 0.3s is smoothed especially. By inputting into the above-mentioned high order interpolator 202, after correcting the desired value over the above-mentioned angle of rotation generated with the above-mentioned desired value generation machine 101 with the above-mentioned rectifier 201, Even when the above-mentioned high order interpolator 202 performs 3rd interpolation, as the solid line of drawing 5 shows, an oscillation does not arise in the desired value after interpolation. About the desired value over the above-mentioned

angle of rotation of drawing 5 by which the oscillation at the time of high order interpolation was prevented, the output of the above-mentioned differentiator 1051 and the proportionality differentiator 1052 is shown in drawing 6 and drawing 7, respectively. As shown in drawing 6 and drawing 7, the desired value over the above-mentioned revolving speed and roll acceleration which were outputted, respectively does not change from the above-mentioned differentiator 1051 and the proportionality differentiator 1052 to rectangle step form, but the desired value over the above-mentioned revolving speed at least is smooth. thereby, in the above-mentioned control device A2, when performing differentiation operation after interpolation, it produces -- flustering -- etc. -- a problem can be suppressed and stable control can be performed. Next, the above-mentioned weighting-factor a_n (a_1, a_2, a_3, --) is given. For example, in a fixed case, sampling period deltaT will calculate the above-mentioned weighting-factor a_N based on a following formula, supposing a linear interpolation operation is expressed by convolution integration with pulse function P_1 (t) and impulse function I (t).

[Equation 3]

$$a_n = \int_{t_{n-1}}^{t_n} P_N(t)dt$$

$$P_N(t_N) = \int_0^{t_N} P_1(t-t_{N-1})P_{N-1}(t_{N-1})dt_{N-1} = \int_0^{t_N} P_1(t-t_{N-1})\int_0^{t_{N-1}} P_1(t-t_{N-2})\cdots\int_0^{t_1} P_1(t-t_0)I(t_0)dt_0\cdots dt_{N-2}dt_{N-1}$$

$$P_1(t) = S(\Delta T, t)$$

$$I(t) = \lim_{x \to 0} S(x,t)$$

$$S(x,t) = \begin{cases} 1/x\ (0 \le t < x) \\ 0\ (t < 0,\ x \le t) \end{cases}$$

Here, pulse function P_1 (t) is collapsed N times, P_N (t) integrates with it, as shown also in the above-mentioned formula, for example, P_2 (t) has the specification in which P_3 (t) interpolates between 3xdeltat for the 3rd characteristic that interpolates between 2xdeltat the 2nd order. The above-mentioned weighting-factor a_n is equivalent to the area of these P_N (t). It is here, and the waveform of P_1 (t) thru/or P_7 (t) is shown in drawing 9, and weighting-factor a_N at the time of N= 4 is shown for the waveform of the square wave function S (x, t) in drawing 10 at drawing 8, respectively. The area of the square wave function S (x, t) as shown in drawing 8, or pulse function P_1 (t) is 1, and the area of impulse function I (t) which carried out ultimate annihilation of this in time is also 1. Therefore, as shown in drawing 9, P_1 (t) thru/or P_7 (t) change the waveform, with the area 1 held. These serve as a known function and can calculate weighting-factor a_n. For example, as shown in drawing 10, weighting-factor a_1 in the case of interpolating between 4xdeltaT the 4th order, a_2, a_3, and a_4 are computed as 1/24, 11/24, and 11/24, respectively. When performing 3rd interpolation like this embodiment, weighting-factor a_1, a_2, and a_3 are computed as 1/6, 4/6, and 1/6, respectively. In order to shorten the time which positioning takes, it is made by the way, more suitable [for the above-

mentioned sampling period deltaT to change]. The above-mentioned weighting-factor a_n will stop however, becoming settled by the above-mentioned operation using linearity convolution integration in such a nonlinear case. Then, the above-mentioned operation is made to generalize more and the above-mentioned weighting-factor a_n is given. Performing N interpolation about between Nxdelta T, i.e., collapse pulse function P_1 (t) N times, and integrate with it, (1) From the output value x and the first floor differential value of its after after N samplings of an impulse response (N-1) to a story differential value can become common on the conditions [total / of 0 (2) impulse response series] 1. As shown in drawing 11, x_N (0), x_N (1), --, x_N (N) have a value, and it In this case, other -- and x_N (-2), and x_N (-1), All of x_N (N+1), x_N (N+2), and -- are set to 0, and the above-mentioned conditions (1) can be expressed like a following formula.

[Equation 4]

$$x_{N-1}(N) = \sum_{n=0}^{N} x_N(n) f_{N-1}(\Delta T(n), \Delta T(n+1)+\cdots+\Delta T(N)) = 0$$

$$x_{N-2}(N) = \sum_{n=0}^{N} x_N(n) f_{N-2}(\Delta T(n), \Delta T(n+1)+\cdots+\Delta T(N)) = 0$$

$$\vdots$$

$$x_1(N) = \sum_{n=0}^{N} x_N(n) f_1(\Delta T(n), \Delta T(n+1)+\cdots+\Delta T(N)) = 0$$

$$x(N) = x_0(N) = \sum_{n=0}^{N} x_N(n) f_0(\Delta T(n), \Delta T(n+1)+\cdots+\Delta T(N)) = 0$$

The above-mentioned conditions (2) can be expressed like a following formula.

[Equation 5]

$$\sum_{k=0}^{N-1} x(k) = 1$$

$$x(k) = x_0(k) = \sum_{n=0}^{k} x_N(k) f_0(\Delta T(n), \Delta T(n+1)+\cdots+\Delta T(k)) = 0 \qquad (k=0,1,\cdots,N-1)$$

f_N (deltaT, T) is in the state which set all the differential values and desired values to 0, (N-1) A story differential value is set to one during the section of deltaT, and by integration calculation, it is an n-th order differential value after the time T at the time of setting a **** value to 0 after it (N-1), and is a computable known function easily, for example, is given like a following formula.

[Equation 6]

$$f_{N-1}(\Delta T, T) = \Delta T$$

$$f_{N-2}(\Delta T, T) = \Delta T \times (\Delta T/2 + T)$$

$$f_{N-3}(\Delta T, T) = \Delta T \times (\Delta T^2/6 + \Delta T T/2 + T^2/2)$$

$$\vdots$$

That is, 2xN+1 strange variable x_N (0), x_N (1), --, 2xN+1 equation containing x_N (N), x (0), x (1), --x (N-1) can express the above-mentioned conditions (1) and (2). In fact, x (0), x (1), --x (N-1) are equivalent to a weighting factor, a_1, a_2, --, a_N among the strange variables drawn from the above-mentioned equation, and, thereby, it can ask for weighting-factor a_N. For example, weighting-factor a_n is called for like a following formula about N= 2 and 3.
[Equation 7]

$$N=2 \rightarrow a_1=\frac{\Delta T(k)}{\Delta T(k)+\Delta T(k+1)},\ a_2=\frac{\Delta T(k+1)}{\Delta T(k)+\Delta T(k+1)}$$

$$N=3 \rightarrow a_1=\frac{\Delta T(k)^2}{(\Delta T(k)+\Delta T(k+1))(\Delta T(k)+\Delta T(k+1)+\Delta T(k+2))},\ a_2=1-a_1-a_3,$$

$$a_3=\frac{\Delta T(k+1)^2}{(\Delta T(k)+\Delta T(k+1))(\Delta T(k-1)+\Delta T(k)+\Delta T(k+1))}$$

Thus, since according to the above-mentioned control device A2 the 3rd desired value over the above-mentioned angle of rotation which performed moving average processing with dignity using the weighting factor defined according to a sampling period is interpolated and feed-forward control is presented with it, A desired value is prevented from oscillating in the case of high order interpolation, and desired values, such as revolving speed which is a differential value of angle of rotation, also become possible [becoming comparatively smooth and performing stable control].
[0006]
[Example]Although this invention was applied in the above-mentioned embodiment to the system which positions the motor 100 which drives a robot, it is also possible for it not to be restricted to this and to apply this invention to the system based on a higher order physical model. In the control device A1 in the above-mentioned embodiment, after generating the desired value over the above-mentioned revolving speed and roll acceleration, the above-mentioned linear interpolation machines 1022 and 1023 performed linear interpolation, respectively, but. It may be made to perform the above-mentioned processing only not only about this but about a desired value [as opposed to the above-mentioned revolving speed for example], and after generating a desired value about desired values, such as rotation jerk, a linear interpolation machine may be made to perform linear interpolation, respectively. Such a control device is also an example of the control device in this invention. In the control device A2 in the above-mentioned embodiment, although the above-mentioned high order interpolator 202 performed 3rd interpolation, not only to this but to N next system subject, it may be made to perform Nth more than interpolation. Such a control device is also an example of the control device in this invention. Although moving average processing with dignity was performed to the desired value over the above-mentioned angle of rotation by the rectifier 201 in the control device A2 in the above-mentioned embodiment, It may be made to give the predetermined dynamic characteristics 2012 besides the moving average processing 2011 with the above-mentioned dignity like control device A3 shown in drawing 12 instead of what is restricted to this. as the above-mentioned dynamic characteristics 2012 -- (z+1) / 2 -- the characteristic of the rectifier 201

in the case of performing secondary interpolation, when the characteristic is given -- $(a_1z+a_2+a_3z^{-1})$ / 1 -- here, weighting-factor a_1, a_2, and a_3 are given with a following formula, respectively.

[Equation 8]

$$a_1 = \frac{\Delta T(k)}{2(\Delta T(k) + \Delta T(k+1))}\ ;\ a_2 = \frac{1}{2},\ a_3 = \frac{\Delta T(k+1)}{2(\Delta T(k) + \Delta T(k+1))}$$

The characteristic of the rectifier 201 in the case of it being also possible to give $c/(1-bz^{-1})$ of revolved type things as the above-mentioned dynamic characteristics 2012, and performing secondary interpolation, Weighting-factor a_1 and a_2 are given with a following formula $c\,(a_1+a_2z^{-1})/(1-bz^{-1})$ here, respectively.

[Equation 9]

$$a_1 = \frac{\Delta T(k)}{\Delta T(k) + \Delta T(k+1)},\ a_2 = \frac{\Delta T(k+1)}{\Delta T(k) + \Delta T(k+1)}$$

Thus, the arbitrary filtering effects etc. can be given by adding predetermined dynamic characteristics to the moving average processing with dignity, suppressing the oscillation at the time of high order interpolation. Such a control device is also an example of the control device in this invention. Although the result of an operation of the high order interpolator 202 was used as it was in the control device A2 concerning the above-mentioned embodiment, When calculating means, such as CPU, perform interpolating calculation, It may be made to correct the interpolating calculation of above-mentioned high order interpolator 202' like control device A4 of drawing 13 in consideration of the point which noises, such as a calculation error, produce using the desired value after being corrected by rectifier 201', the first floor differential value of its, --, N story differential value. In above-mentioned control device A4, positions, such as angle of rotation, the first floor differential value (speed) of those, --, a desired value sequence including N story differential value are generated by desired value generation machine 101'. After the moving average processing with dignity is made by rectifier 201' and this desired value sequence is corrected, it is taken out by the sampler group 102 with a predetermined sampling period, and is outputted to high order interpolator 202'. In above-mentioned high order interpolator 202', story differential value $p^{(N-1)}$ (k) from first floor differential value $p^{(1)}$ (k) of the desired value after the interpolation currently held by the inside (N-1) by the above-mentioned sampler group 102. Taken-out $P^{(1)}$ It is corrected by story differential value $P^{(N-1)}$ (k) from (k) at the time of sampling time T (k) (N-1), and a calculation error is removed. Story differential value $P^{(N-1)}$ (k) is computable from $P^{(1)}$ (k) by moving average processing with dignity as well as correction of a desired value (N-1). For example, the weighting factor in the case of the differential value derivation at the time of the 2 or 3rd interpolation is given with a following formula, respectively.

[Equation 10]

N=2 →

$$a_1^{(1)} = \frac{2}{\Delta T(k) + \Delta T(k+1)}, \quad a_2^{(1)} = \frac{-2}{\Delta T(k) + \Delta T(k+1)}$$

N=3 →

$$a_1^{(1)} = \frac{3\,\Delta T(k)}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k) + \Delta T(k+1) + \Delta T(k+2))}$$

$$a_2^{(1)} = \frac{-3\,\Delta T(k)}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k) + \Delta T(k+1) + \Delta T(k+2))} + \frac{3\,\Delta T(k+1)}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k-1) + \Delta T(k) + \Delta T(k+1))}$$

$$a_3^{(1)} = \frac{-3\,\Delta T(k+1)}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k-1) + \Delta T(k) + \Delta T(k+1))}$$

$$a_1^{(2)} = \frac{6}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k) + \Delta T(k+1) + \Delta T(k+2))}$$

$$a_2^{(2)} = \frac{-6}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k) + \Delta T(k+1) + \Delta T(k+2))} + \frac{-6}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k-1) + \Delta T(k) + \Delta T(k+1))}$$

$$a_3^{(2)} = \frac{6}{(\Delta T(k) + \Delta T(k+1))(\Delta T(k-1) + \Delta T(k) + \Delta T(k+1))}$$

However, $a_n^{(i)}$ is the n-th weighting factor of i story differential value. Thus, according to above-mentioned control device A4, it becomes possible by canceling noises, such as a calculation error in high order interpolator 202', to perform more stable control. Although the rectifier 201 was formed in the higher rank system containing the desired value generation machine 101 in the control device A2 grade concerning the above-mentioned embodiment, It may be made to have the above-mentioned dynamic characteristics which include the moving average processing with dignity in high order interpolator 202" like control device A5 of drawing 14 instead of what is restricted to this. Such a control device is also an example of the control device in this invention. In the control device A2 in the above-mentioned embodiment, when changing predetermined sampling period deltaT, based on the above-mentioned conditions (1) and the function corresponding to (2), defined weighting-factor a_n, but. In addition, from the first floor differential value of the output value after the sampling time (N-1) time of (4) step responses whose output value after the sampling time (N-1) time of (3) step responses corresponds with a step-input value (N-1) to a time differential value. It may be made to define the above-mentioned weighting factor based on the function corresponding to the conditions of ** 0. It may be made to set based on a following condition (5) and the function corresponding to (6). (5) In the response corresponding to (6) arbitrary input an output value and whose input value correspond when the constant value between N sampling time is inputted in the response corresponding to an arbitrary input. When the constant value between N sampling time is inputted,

the control device with which from the first floor differential value of an output value (N-1) to the time differential value used such a weighting factor zero is also an example of the control device in this invention.

[0007]

[Effect of the Invention]When only a predetermined time interval requires time for generation of the desired value over the position of the subject generated from a position target value creating means according to the control device given in any 1 paragraph of above-mentioned claims 1-3, the desired value over the above-mentioned position by for example, speed target value generating means, such as a differentiator. Since linear interpolation is performed by the above-mentioned speed interpolation means after changing into the desired value over the speed of the above-mentioned subject, in the feed-forward control to the speed of the above-mentioned subject, the desired value over the above-mentioned speed is prevented from changing to step form at least, and it can stabilize control. According to the control device given in any 1 paragraph of above-mentioned claims 4-13, since Nth high order more than interpolation is performed about the desired value over the position of N next system subject, each desired value can be prevented from changing with the differentiation operations in the case of control to rectangle step form, and control can be stabilized more. The oscillation of the desired value after the interpolation at the time of high order interpolation can be prevented by performing data smoothing which added predetermined dynamic characteristics to the moving average processing with dignity, or it especially.

[Translation done.]